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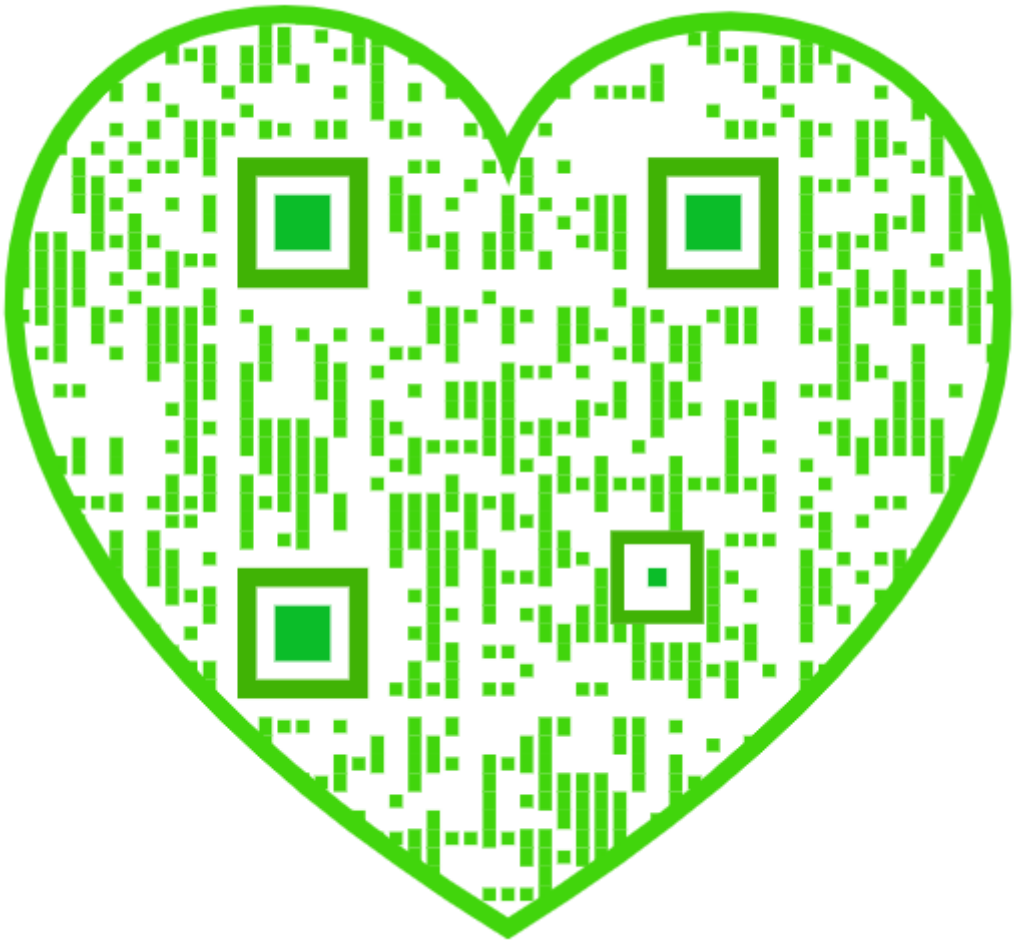
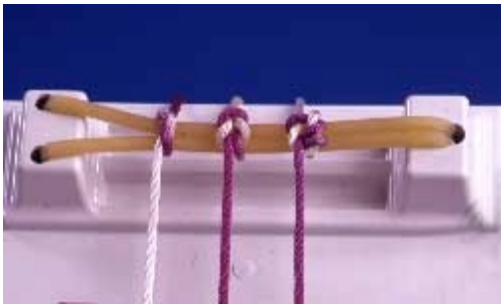


Basic Knots

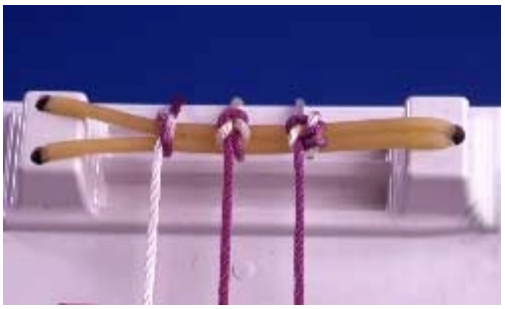
The knots demonstrated on the following pages are those most frequently used, and are applicable to all types of operative procedures. The camera was placed behind the demonstrator so that each step of the knot is shown as seen by the operator. For clarity, one-half of the strand is purple and the other white. *The purple working strand is initially held in the right hand.* The left-handed person may choose to study the photographs in a mirror.



1. **Simple knot:** incomplete basic unit
2. **Square knot:** completed knot
3. **Surgeon's or Friction knot:** completed tension knot

Knot Security

The knots demonstrated on the following pages are those most frequently used, and are applicable to all types of operative procedures. The camera was placed behind the demonstrator so that each step of the knot is shown as seen by the operator. For clarity, one-half of the strand is purple and the other white. *The purple working strand is initially held in the right hand.* The left-handed person may choose to study the photographs in a mirror.



1. **Simple knot:** incomplete basic unit
2. **Square knot:** completed knot
3. **Surgeon's or Friction knot:** completed tension knot

Knot Security

The construction of ETHICON* sutures has been carefully designed to produce the optimum combination of strength, uniformity, and hand for each material. The term *hand* is the most subtle of all suture quality aspects. It relates to the feel of the suture in the surgeon's hands, the smoothness with which it passes through tissue and ties down, the way in which knots can be set and snugged down, and most of all, to the firmness or body of the suture. *Extensibility* relates to the way in which the suture will stretch slightly during knot tying and then recover. The stretching characteristics provide the signal that alerts the surgeon to the precise moment when the suture knot is snug.

Multifilament sutures are generally easier to handle and to tie than monofilament sutures, however, all the synthetic materials require a specific knotting technique. With multifilament sutures, the nature of the material and the braided or twisted construction provide a high coefficient of friction and the knots remain as they are laid down. In monofilament sutures, on the other hand, the coefficient of friction is relatively low, resulting in a greater tendency for the knot to loosen after it has been tied. In addition, monofilament synthetic polymeric materials possess the property of memory. *Memory* is the tendency not to lie flat, but to return to a given shape set by the material's extrusion process or the suture's packaging. The RELAY* suture delivery system delivers sutures with minimal package memory due to its unique package design.

Suture knots must be properly placed to be secure. Speed in tying knots may result in less than perfect placement of the strands. In addition to variables inherent in the suture materials, considerable variation can be found between knots tied by different surgeons and even between knots tied by the same individual on different occasions.

General Principles of Knot Tying

Certain general principles govern the tying of all knots and apply to all suture materials.

1. The completed knot must be firm, and so tied that slipping is virtually impossible. The simplest knot for the material is the most desirable.

2. The knot must be as small as possible to prevent an excessive amount of tissue reaction when absorbable sutures are used, or to minimize foreign body reaction to nonabsorbable sutures. Ends should be cut as short as possible.

3. In tying any knot, friction between strands ("sawing") must be avoided as this can weaken the integrity of the suture.

4. Care should be taken to avoid damage to the suture material when handling. Avoid the crushing or crimping application of surgical instruments, such as needleholders and forceps, to the strand except when grasping the free end of the suture during an instrument tie.

5. Excessive tension applied by the surgeon will cause breaking of the suture and may cut tissue. Practice in avoiding excessive tension leads to successful use of finer gauge materials.

6. Sutures used for approximation should not be tied too tightly, because this may contribute to tissue strangulation.

7. After the first loop is tied, it is necessary to maintain traction on one end of the strand to avoid loosening of the throw if being tied under any tension.

8. Final tension on final throw should be as nearly horizontal as possible.

9. The surgeon should not hesitate to change stance or position in relation to the patient in order to place a knot securely and flat.

10. Extra ties do not add to the strength of a properly tied knot. They only contribute to its bulk. With some synthetic materials, knot security requires the standard surgical technique of flat and square ties with additional throws if indicated by surgical circumstance and the experience of the surgeon.

An important part of good suturing technique is correct method in knot tying. A seesaw motion, or the sawing of one strand down over another until the knot is formed, may materially weaken sutures to the point that they may break when the second throw is made or, even worse, in the postoperative period when the suture is further weakened by increased tension or motion.

If the two ends of the suture are pulled in opposite directions with uniform rate and tension, the knot may be tied more securely. This point is well-illustrated in the knot tying techniques shown in the next section of this manual.

Square Knot

Square Knot Pictures

Two-Hand Technique

One-Hand Technique

Two Hand Technique

Square Knot **Two-Hand Technique**

The two-hand square knot is the easiest and most reliable for tying most suture materials. It may be used to tie surgical gut, virgin silk, surgical cotton, and surgical stainless steel.

Standard technique of flat and square ties with additional throws if indicated by the surgical circumstance and the experience of the operator should be used to tie PANACRYL* braided synthetic absorbable suture, MONOCRYL* (poliglecaprone 25) suture, Coated VICRYL* (polyglactin 910) suture, Coated VICRYL *RAPIDE** (polyglactin 910) suture, PDS* II (polydioxanone) suture, ETHILON* nylon suture, ETHIBOND* *EXCEL* polyester suture, PERMA-HAND* silk suture, PRONOVA* poly (hexafluoropropylene-VDF) suture, and PROLENE* polypropylene suture.

1 White strand placed over extended index finger of left hand acting as bridge, and held in palm of left hand. Purple strand held in right hand.

Purple strand held in right hand brought between left thumb and index finger. 2

3

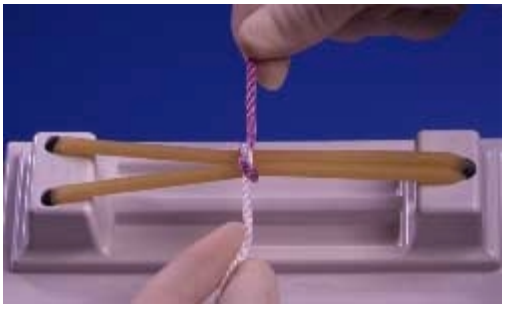
Left hand turned inward by pronation, and thumb swung under white strand to form the first loop.

Purple strand crossed over white and held between thumb and index finger of left hand.

4

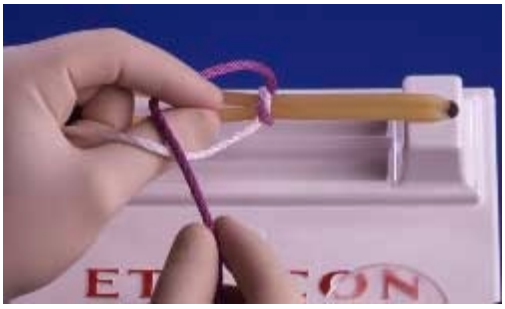
Square Knot **Two-Hand Technique**

5 Right hand releases purple strand. Then left hand supinated, with thumb and index finger still grasping purple strand, to bring purple strand through the white loop. Regrasp purple strand with right hand.



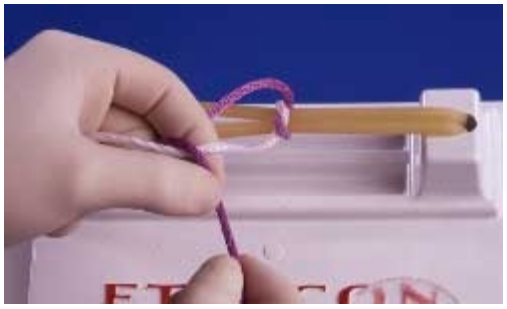
Purple strand released by left hand and grasped by right. Horizontal tension is applied with left hand toward and right hand away from operator. This completes first half hitch. 6

7 Left index finger released from white strand and left hand again supinated to loop white strand over left thumb. Purple strand held in right hand is angled slightly to the left.



Purple strand brought toward the operator with the right hand and placed between left thumb and index finger. Purple strand crosses over white strand. 8

Square Knot **Two-Hand Technique**



9

By further supinating left hand, white strand slides onto left index finger to form a loop as purple strand is grasped between left index finger and thumb.

10

Left hand rotated inward by pronation with thumb carrying purple strand through loop of white strand. Purple strand is grasped between right thumb and index finger.

11

Horizontal tension applied with left hand away from and right hand toward the operator. This completes the second half hitch.

12

The final tension on the final throw should be as nearly horizontal as possible.

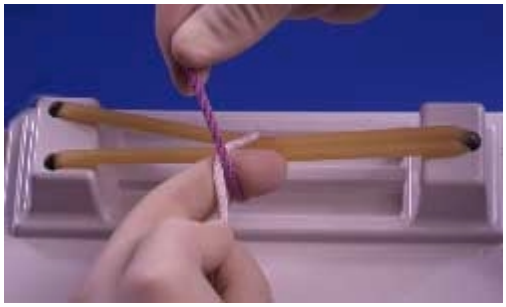
One-Handed Technique

Square Knot **One-Hand Technique**

Wherever possible, the square knot is tied using the two-hand technique. On some occasions it will be necessary to use one hand, either the left or the right, to tie a square knot. These illustrations employ the left-handed technique.

The sequence of throws illustrated is most commonly used for tying single suture strands. The sequence may be reversed should the surgeon be holding a reel of suture material in the right hand and placing a series of ligatures. In either case, it cannot be too strongly emphasized that the directions the hands travel must be reversed proceeding from one throw to the next to ensure that the knot formed lands flat and square. Half hitches result if this precaution is not taken.

1 White strand held between thumb and index finger of left hand with loop over extended index finger. Purple strand held between thumb and index finger of right hand.



Purple strand brought over white strand on left index finger by moving right hand away from operator. 2

3	With purple strand supported in right hand, the distal phalanx of left index finger passes under the white strand to place it over tip of left index finger. Then the white strand is pulled through loop in preparation for applying tension.	The first half hitch is completed by advancing tension in the horizontal plane with the left hand drawn toward and right hand away from the operator.

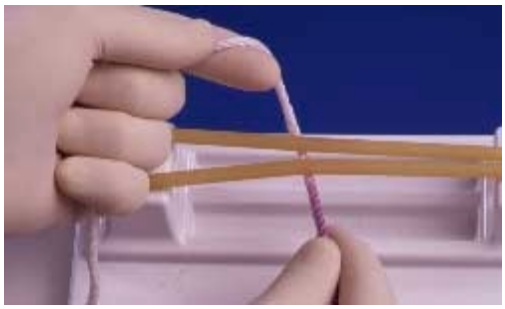
Surgeon’s or Friction Knot

Surgeon's or Friction Knot

The surgeon's or friction knot is recommended for tying PANACRYL* braided synthetic absorbable suture, Coated VICRYL* (polyglactin 910) suture, ETHIBOND* *EXCEL* polyester suture, ETHILON* nylon suture, MERSILENE* polyester fiber suture, NUROLON* nylon suture,

PRONOVA* poly (hexafluoropropylene-VDF) suture, and PROLENE* polypropylene suture.

The surgeon's knot also may be performed using a one-hand technique in a manner analogous to that illustrated for the square knot one-hand technique.



1 White strand placed over extended index finger of left hand and held in palm of left hand. Purple strand held between thumb and index finger of right hand.

Purple strand crossed over white strand by moving right hand away from operator at an angle to the left. Thumb and index finger of left hand pinched to form loop in the white strand over index finger. 2

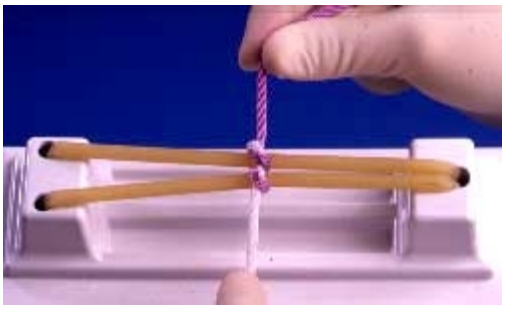
3	Left hand turned inward by pronation, and loop of white strand slipped onto left thumb. Purple strand grasped between thumb and index finger of left hand. Release right hand.	Left hand rotated by supination extending left index finger to pass purple strand through loop. Regrasp purple strand with right hand.

Surgeon's or Friction Knot

5 The loop is slid onto the thumb of the left hand by pronating the pinched thumb and index finger of left hand beneath the loop.

Purple strand drawn left with right hand and again grasped between thumb and index finger of left hand. 6

7 Left hand rotated by supination extending left index finger to again pass purple strand through forming a double loop.



Horizontal tension is applied with left hand toward and right hand away from the operator. This double loop must be placed in precise position for the final knot. 8

Surgeon's or Friction Knot

9 With thumb swung under white strand, purple strand is grasped between thumb and index finger of left hand and held over white strand with right hand.

Purple strand released. Left hand supinates to regrasp purple strand with index finger beneath the loop of the white strand. 10

11 Purple strand rotated beneath the white strand by supinating pinched thumb and index finger of left hand to draw purple strand through the loop. Right hand regrasps purple strand to complete

Hands continue to apply horizontal tension with left hand away from and right hand toward the operator. Final tension on final throw should be as nearly horizontal as possible.

the second throw square.

Deep Tie

Deep Tie
Page 1 of 2

Tying deep in a body cavity can be difficult. The square knot must be firmly snugged down as in all situations.

However the operator must avoid upward tension which may tear or avulse the tissue.

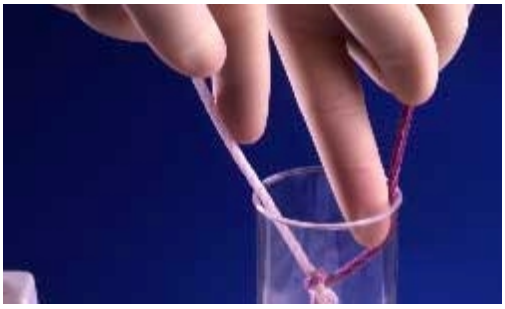
1 Strand looped around hook in plastic cup on Practice Board with index finger of right hand which holds purple strand in palm of hand. White strand held in left hand.

Purple strand held in right hand brought between left thumb and index finger. Left hand turned inward by pronation, and thumb swung under white strand to form the first loop. 2

3	By placing index finger of left hand on white strand, advance the loop into the cavity.	Horizontal tension applied by pushing down on white strand with left index finger while maintaining counter-tension with index finger of right hand on purple strand.	4

5 Purple strand looped over and under white strand with right hand.

6 Purple strand looped around white strand to form second loop. This throw is advanced into the depths of the cavity.



7 Horizontal tension applied by pushing down on purple strand with right index finger while maintaining counter-tension on white strand with left index finger. Final tension should be as nearly horizontal as possible.

Ligation Around Hemostatic Clamp

Ligation Around Memostatic Clamp -More Common of Two Methods

Frequently it is necessary to ligate a blood vessel or tissue grasped in a hemostatic clamp to achieve hemostasis in the operative field.

1 When sufficient tissue has been cleared away to permit easy passage of the suture ligature, the white strand held in the right hand is passed behind the clamp.

Left hand grasps free end of the strand and gently advances it behind clamp until both ends are of equal length. 2

3 To prepare for placing the knot

As the first throw of the knot is completed, the 4

square, the white strand is transferred to the right hand and the purple strand to the left hand, thus crossing the white strand over the purple.	assistant removes the clamp. This maneuver permits any tissue that may have been bunched in the clamp to be securely crushed by the first throw. The second throw of the square knot is then completed with either a two-hand or one-hand technique as previously illustrated.

Ligation Around Hemostatic Clamp -Alternate Technique

Some surgeons prefer this technique because the operator never loses contact with the suture ligature as in the preceding technique.

1 Center of the strand placed in front of the tip of hemostatic clamp with purple strand held in right hand and white strand in left hand.

Purple strand swung behind clamp and grasped with index finger of left hand. Purple strand will be transferred to left hand and released by right. 2

3 Purple strand crossed under white strand with left index finger and regrasped

First throw is completed in usual manner. Tension is placed on both strands 4

with right hand.	below the tip of the clamp as the first throw of the knot is tied. The assistant then removes the clamp. The square knot is completed with either a two-hand or one-hand technique as previously illustrated.

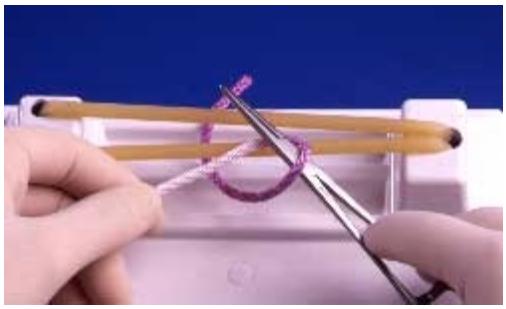
Instrument Tie

Instrument Tie

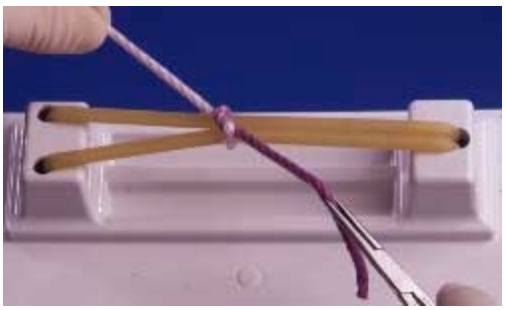
The instrument tie is useful when one or both ends of the suture material are short. For best results, exercise caution when using a needleholder with PANACRYL* braided synthetic

absorbable suture or any monofilament suture, as repeated bending may cause these sutures to break.

1 Short purple strand lies freely. Long white end of strand held between thumb and index finger of left hand. Loop formed by placing needleholder on side of strand away from the operator.

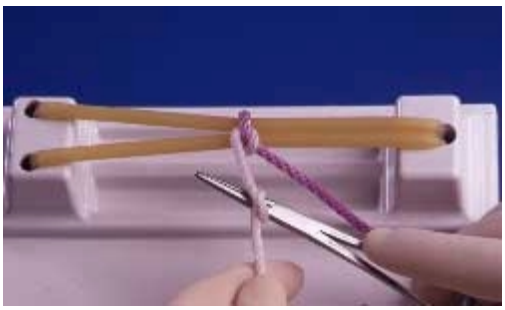


Needleholder in right hand grasps short purple end of strand. 2



3

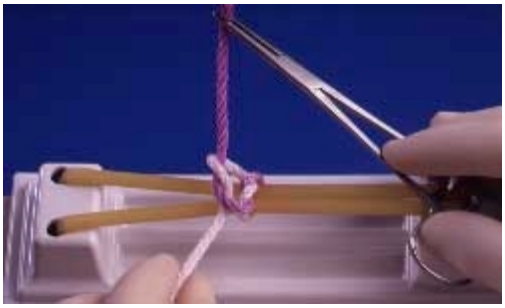
First half hitch completed by pulling needleholder toward operator with right hand and drawing white strand away from operator. Needleholder is released from purple strand.



4

White strand is drawn toward operator with left hand and looped around needleholder held in right hand. Loop is formed by placing needleholder on side of strand toward the operator.

Instrument Tie



5

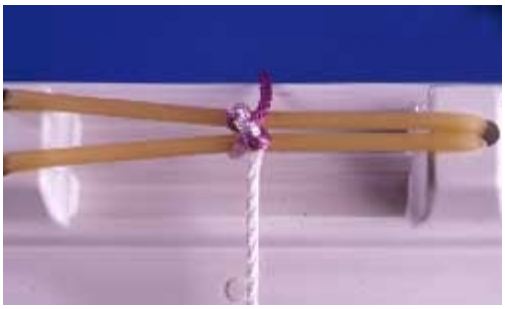
With end of the strand grasped by the needleholder, purple strand is drawn through loop in the white strand away from the operator.

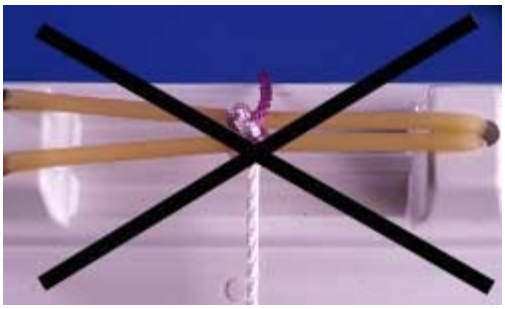
6

Square knot completed by horizontal tension applied with left hand holding white strand toward operator and purple strand in needleholder away from operator. Final tension should be as nearly horizontal as possible.

Granny Knot

A granny knot is not recommended. However, it may be inadvertently tied by incorrectly crossing the strands of a square knot. It is shown only to warn against its use. It has the tendency to slip when subjected to increasing pressure.





Suture Materials

The requirement for wound support varies in different tissues from a few days for muscle, subcutaneous tissue, and skin; weeks or months for fascia and tendon; to long-term stability, as for a vascular prosthesis. The surgeon must be aware of these differences in the healing rates of various tissues and organs. In addition, factors present in the individual patient, such as infection, debility, respiratory problems, obesity, etc., can influence the postoperative course and the rate of healing.

Suture selection should be based on the knowledge of the physical and biologic characteristics of the material in relationship to the healing process. The surgeon wants to ensure that a suture will retain its strength until the tissue regains enough strength to keep the wound edges together on its own. In some tissue that might never regain preoperative strength, the surgeon will want suture material that retains strength for a long time. If a suture is going to be placed in tissue that heals rapidly, the surgeon may prefer to select a suture that will lose its tensile strength at about the same rate as the tissue gains strength and that will be absorbed by the tissue so that no foreign material remains in the wound once the tissue has healed. With all sutures, acceptable surgical practice must be followed with respect to drainage and closure of infected wounds. The amount of tissue reaction caused by the suture encourages or retards the healing process.

When all these factors are taken into account, the surgeon has several choices of suture materials available. Selection can then be made on the basis of familiarity with the material, its ease of handling, and other subjective preferences.

Sutures can conveniently be divided into two broad groups: absorbable and nonabsorbable. Regardless of its composition, suture material is a *foreign body* to the human tissues in which it is implanted and to a greater or lesser degree will elicit a foreign body reaction.

Two major mechanisms of absorption result in the degradation of absorbable sutures. Sutures of biological origin such as surgical gut are gradually digested by tissue enzymes. Sutures manufactured from synthetic polymers are principally broken down by hydrolysis in tissue fluids.

Nonabsorbable sutures made from a variety of nonbio-degradable materials are ultimately encapsulated or walled off by the body?s fibroblasts. Nonabsorbable sutures ordinarilv remain where thev

are buried within the tissues. When used for skin closure, they must be removed postoperatively.

A further subdivision of suture materials is useful: monofilament and multifilament. A *monofilament* suture is made of a single strand. It resists harboring microorganisms, and it ties down smoothly. A *multifilament* suture consists of several filaments twisted or braided together. This gives good handling and tying qualities. However, variability in knot strength among multifilament sutures might arise from the technical aspects of the braiding or twisting process.

The sizes and tensile strengths for all suture materials are standardized by U.S.P. regulations. Size denotes the diameter of the material. Stated numerically, the more zeroes (0's) in the number, the smaller the size of the strand. As the number of 0's decreases, the size of the strand increases. The 0's are designated as 5-0, for example, meaning 00000 which is smaller than a size 4-0. The smaller the size, the less tensile strength the strand will have. Tensile strength of a suture is the measured pounds of tension that the strand will withstand before it breaks when knotted. **(Refer to Absorbable Sutures & Nonabsorbable Sutures section)**

Principles of Suture Selection

The surgeon has a choice of suture materials from which to select for use in body tissues. Adequate strength of the suture material will prevent suture breakage. Secure knots will prevent knot slippage. But the surgeon must understand the nature of the suture material, the biologic forces in the healing wound, and the interaction of the suture and the tissues. The following principles should guide the surgeon in suture selection.

1. When a wound has reached maximal strength, sutures are no longer needed. Therefore:

a. Tissues that ordinarily heal slowly such as skin, fascia, and tendons should usually be closed with nonabsorbable sutures. An absorbable suture with extended (up to 6 months) wound support may also be used.

b. Tissues that heal rapidly such as stomach,colon, and bladder may be closed with absorbable sutures.

2. Foreign bodies in potentially contaminated tissues may convert contamination to infection. Therefore:

a. Avoid multifilament sutures which may convert a contaminated wound into an infected one.

b. Use monofilament or absorbable sutures in potentially contaminated tissues.

3. Where cosmetic results are important, close and prolonged apposition of wounds and avoidance of irritants will produce the best result. Therefore:

a. Use the smallest inert monofilament suture materials such as nylon or polypropylene.

b. Avoid skin sutures and close subcuticularly, whenever possible.

c. Under certain circumstances, to secure close apposition of skin edges, a topical skin adhesive or skin closure tape may be used.

4. Foreign bodies in the presence of fluids containing high concentrations of crystalloids may act as a nidus for precipitation and stone formation. Therefore:

a. In the urinary and biliary tract, use rapidly absorbed

sutures.

5. Regarding suture size:

a. Use the finest size, commensurate with the natural strength of the tissue.

b. If the postoperative course of the patient may produce sudden strains on the suture line, reinforce it with retention sutures. Remove them as soon as the patient?s condition is stabilized.

Metric Measures and U.S.P Suture Diameter Equivalents

U.S.P. Size	11-0	10-0	9-0	8-0	7-0	6-0	5-0	4-0	3-0	2-0	0	1	2	3	4	5	6
Natural Collagen	-	0.2	0.3	0.5	0.7	1.0	1.5	2.0	3.0	3.5	4.0	5.0	6.0	7.0	8.0	-	-
Synthetic Absorbables	-	0.2	0.3	0.4	0.5	0.7	1.0	1.5	2.0	3.0	3.5	4.0	5.0	6.0	6.0	7.0	-
Nonabsorbable Materials	0.1	0.2	0.3	0.4	0.5	0.7	1.0	1.5	2.0	3.0	3.5	4.0	5.0	6.0	6.0	7.0	8.0

Absorbable Sutures

Absorbable Sutures

Page 1

The United States Pharmacopeia (U.S.P.) defines an absorbable surgical suture as a "sterile strand prepared from collagen derived from healthy mammals or a synthetic polymer. It is capable of being absorbed by living mammalian tissue, but may be treated to modify its resistance to absorption. It may be impregnated or coated with a suitable antimicrobial agent. It may be colored by a color additive approved by the Federal Food and Drug Administration (F.D.A.)."

The United States Pharmacopeia, Twentieth Revision, Official from July 1, 1980.

Absorbable Suture Materials Most Commonly Used

SUTURE	TYPES	COLOR OF MATERIAL	RAW MATERIAL	TENSILE STRENGTH RETENTION *in vivo*	ABSORPTION RATE
Surgical Gut Suture	Plain	Yellowish-tan Blue Dyed	Collagen derived from healthy beef and sheep.	Individual patient characteristics can affect rate of tensile strength loss.	Absorbed by proteolytic enzymatic digestive process.
Surgical Gut Suture	Chromic	Brown Blue Dyed	Collagen derived from healthy beef and sheep.	Individual patient characteristics can affect rate of tensile strength loss.	Absorbed by proteolytic enzymatic digestive process.
Coated VICRYL (polyglactin 910) Suture	Braided Monofilament	Violet Undyed (Natural)	Copolymer of lactide and glycolide coated with polyglactin 370 and calcium stearate.	Approximately 75% remains at two weeks. Approximately 50% remains at three weeks.	Essentially complete between 56-70 days. Absorbed by hydrolysis.
Coated	Braided	Undyed	Copolymer of lactide	Approximately	Essentially

VICRYL *RAPIDE* (polyglactin 910) Suture		(Natural)	and glycolide coated with polyglactin 370 and calcium stearate.	50% remains at 5 days. All tensile strength is lost at approximately 14 days.	complete by 42 days. Absorbed by hydrolysis.
MONOCRYL (poliglecaprone 25) Suture	Monofilament	Undyed (Natural) Violet	Copolymer of glycolide and epsilon-caprolactone.	Approximately 50-60% (violet: 60-70%) remains at one week. Approximately 20-30% (violet: 30-40%) remains at two weeks. Lost within three weeks (violet: four weeks).	Complete at 91-119 days. Absorbed by hydrolysis.
PDS II (polydioxanone) Suture	Monofilament	Violet Blue Clear	Polyester polymer.	Approximately 70% remains at two weeks. Approximately 50% remains at four weeks. Approximately 25% remains at six weeks.	Minimal until about 90th day. Essentially complete within six months. Absorbed by slow hydrolysis.
PANACRYL Braided Synthetic Absorbable Suture	Braided	Undyed (White)	Copolymer of lactide and glycolide coated with caprolactone/glycolide.	Approximately 80% remains at 3 months. Approximately 60% remains at 6 months. Approximately 20% remains at 12 months.	Essentially complete between 18 and 30 months. Absorbed by slow hydrolysis.

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Absorbable Sutures

The United States Pharmacopeia (U.S.P.) defines an absorbable surgical suture as a "sterile strand prepared from collagen derived from healthy mammals or a synthetic polymer. It is capable of being absorbed by living mammalian tissue, but may be treated to modify its resistance to absorption. It may be impregnated or coated with a suitable antimicrobial agent. It may be colored by a color additive approved by the Federal Food and Drug Administration (F.D.A.)."

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SUTURE	CONTRAINDICATIONS	FREQUENT USES	HOW SUPPLIED	COLOR CODE OF PACKETS
Moderate reaction	Being absorbable, should not be used where extended approximation of tissues under stress is required. Should not be used in patients with known sensitivities or allergies to collagen or chromium.	General soft tissue approximation and/or ligation, including use in ophthalmic procedures. Not for use in cardiovascular and neurological tissues.	7-0 thru 3 with and without needles, and on LIGAPAK dispensing reels 0 thru 1 with CONTROL RELEASE needles	Yellow
Moderate reaction	Being absorbable, should not be used where extended approximation of tissues under stress is required. Should not be used in patients with known sensitivities or allergies to collagen or chromium.	General soft tissue approximation and/or ligation, including use in ophthalmic procedures. Not for use in	7-0 thru 3 with and without needles, and on LIGAPAK dispensing reels 0 thru 1	Beige

		cardiovascular and neurological tissues.	with CONTROL RELEASE needles	
Minimal acute inflammatory reaction	Being absorbable, should not be used where extended approximation of tissue is required.	General soft tissue approximation and/or ligation, including use in ophthalmic procedures. Not for use in cardiovascular and neurological tissues.	8-0 thru 3 with and without needles, and on LIGAPAK dispensing reels 4-0 thru 2 with CONTROL RELEASE needles 8-0 with attached beads for ophthalmic use	Violet
Minimal to moderate acute inflammatory reaction	Should not be used where extended approximation of tissue under stress is required or where wound support beyond 7 days is required.Superficial soft tissue approximation of skin and mucosa only. Not for use in ligation, ophthalmic, cardiovascular or neurological procedures. 5-0 thru 1 with needles.	Superficial soft tissue approximation of skin and mucosa only. Not for use in ligation, ophthalmic, cardiovascular or neurological procedures.	.5-0 thru 1 with needles.	Violet and Red
Minimal acute inflammatory	Being absorbable, should not be used where extended approximation of tissue under stress is required. Undyed not indicated for use in fascia.	General soft tissue approximation and/or ligation. Not for use in cardiovascular	6-0 thru 2 with and without needles 3-0 thru 1 with	Coral

		or neurological tissues, microsurgery, or ophthalmic surgery.	CONTROL RELEASE needles.	
Slight reaction	Being absorbable, should not be used where prolonged approximation of tissues under stress is required. Should not be used with prosthetic devices, such as heart valves or synthetic grafts.	All types of soft tissue approximation, including pediatric cardiovascular and ophthalmic procedures. Not for use in adult cardiovascular tissue, microsurgery, and neural tissue.	9-0 thru 2 with needles 4-0 thru 1 with CONTROL RELEASE needles 9-0 thru 7-0 with needles 7-0 thru 1 with needles	Silver
Minimal acute inflammatory reaction	Being absorbable, should not be used where extended approximation of tissue beyond six months is required.	General soft tissue approximation and/or ligation, and orthopaedic uses including tendon and ligament repairs and reattachment to bone. Particularly useful where extended wound support (up to 6 months) is desirable. Not for use in ophthalmic, cardiovascular,	2-0 through 2 with needles 2-0 through 1 with CONTROL RELEASE needles	Purple

		or neurological tissue.		

Nonabsorbable Sutures

Nonabsorbable Sutures

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By U.S.P. definition, "nonabsorbable sutures are strands of material that are suitably resistant to the action of living mammalian tissue. A suture may be composed of a single or multiple filaments of metal or organic fibers rendered into a strand by spinning, twisting, or braiding. Each strand is substantially uniform in diameter throughout its length within U.S.P. limitations for each size. The material may be uncolored, naturally colored, or dyed with an F.D.A. approved dyestuff. It may be coated or uncoated; treated or untreated for capillarity."

Nonabsorbable Suture Materials Most Commonly Used

SUTURE	TYPES	COLOR OF MATERIAL	RAW MATERIAL	TENSILE STRENGTH RETENTION *in vivo*	ABSORPTION RATE
PERMA-HAND Silk Suture	Braided	Violet White	Organic protein called fibroin.	Progressive degradation of fiber may result in gradual loss of tensile strength over time.	Gradual encapsulation by fibrous connective tissue.
Surgical Stainless Steel Suture	Monofilament Multifilament	Silver metallic	316L stainless steel.	Indefinite.	Nonabsorbable.
ETHILON Nylon Suture	Monofilament	Violet Green Undyed (Clear)	Long-chain aliphatic polymers Nylon 6 or Nylon 6,6.	Progressive hydrolysis may result in gradual loss of tensile strength over time.	Gradual encapsulation by fibrous connective tissue.

NUROLON Nylon Suture	Braided	Violet Green Undyed (Clear)	Long-chain aliphatic polymers Nylon 6 or Nylon 6,6.	Progressive hydrolysis may result in gradual loss of tensile strength over time.	Gradual encapsulation by fibrous connective tissue.
MERSILENE Polyester Fiber Suture	Braided Monofilament	Green Undyed (White)	Poly (ethylene terephthalate).	No significant change known to occur *in vivo.*	Gradual encapsulation by fibrous connective tissue.
ETHIBOND *EXCEL* Polyester Fiber Suture	Braided	Green Undyed (White)	Poly (ethylene terephthalate) coated with polybutilate.	No significant change knownto occur *in vivo.*	Gradual encapsulation by fibrous connective tissue.
PROLENE Polypropylene Suture	Monofilament	Clear Blue	Isotactic crystalline stereoisomer of polypropylene.	Not subject to degradation or weakening by action of tissue enzymes.	Nonabsorbable.
PRONOVA* Poly (hexafluoropropylene-VDF) Suture	Monofilament	Blue	Polymer blend of poly (vinylidene fluoride) and poly (vinylidene fluoride-co-hexafluoropropylene).	Not subject to degradation or weakening by action of tissue enzymes.	Nonabsorbable.

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Nonabsorbable Sutures

By U.S.P. definition, "nonabsorbable sutures are strands of material that are suitably resistant to the action of living mammalian tissue. A suture may be composed of a single or multiple filaments of metal or organic fibers rendered into a strand by spinning, twisting, or braiding. Each strand is substantially uniform in diameter throughout its length within U.S.P. limitations for each size. The material may be uncolored, naturally colored, or dyed with an F.D.A. approved dyestuff. It may be coated or uncoated; treated or untreated for capillarity."

TISSUE REACTION	CONTRAINDICATIONS	FREQUENT USES	HOW SUPPLIED	COLOR CODE OF PACKETS
Acute inflammatory reaction	Should not be used in patients with known sensitivities or allergies to silk	General soft tissue approximation and/or ligation, including cardiovascular, opthalmic and neaurological procedures.	9-0 thru 5 with and without needles, and on LIGAPAK dispensing reels 4-0 thru 1 with CONTROL RELEASE needles	Light Blue
Minimal acute inflammatory reaction	Should not be used in patients with known sensitivities or allergies to 316L stainless steel, or constituent metals such as chromium and nickel.	Abdominal wound closure, hernia repair, sternal closure and orthopaedic procedures including cerclage and tendon repair.	10-0 thru 7 with and without needles	Yellow-Ochre

Minimal acute inflammatory reaction	Should not be used where permanent retention of tensile strength is required.	General soft tissue approximation and/or ligation, including use in cardiovascular, ophthalmic and neurological procedures.	11-0 thru 2 with and without needles	Mint Green
Minimal acute inflammatory reaction	Should not be used where permanent retention of tensile strength is required.	General soft tissue approximation and/or ligation, including use in cardiovascular, ophthalmic and neurological procedures.	6-0 thru 1 with and without needles 4-0 thru 1 with CONTROL RELEASE needles	Mint Green
Minimal acute inflammatory reaction	None known.	General soft tissue approximation and/or ligation, including use in cardiovascular, ophthalmic and neurological procedures.	6-0 thru 5 with and without needles 10-0 and 11-0 for opthalmic (green monofilament) 0 with CONTROL RELEASE needles	Turquoise
Minimal acute inflammatory reaction	None known.	General soft tissue approximation and/or ligation, including use	7-0 thru 5 with and without needles 4-0 thru 1	Orange

		including use in cardiovascular, ophthalmic and neurological procedures.	with CONTROL RELEASE needles various sizes attached to TFE polymer pledgets	
Minimal acute inflammatory reaction	None known.	General soft tissue approximation and/or ligation, including use in cardiovascular, ophthalmic and neurological procedures.	6-0 thru 2 (clear) with and without needles 10-0 thru 8-0 and 6-0 thru 2 (blue) with and without needles 0 thru 2 wuth CONTROL RELEASE needles various sizes attached to TFE polymer pledgets	Deep Blue
Minimal acute inflammatory reaction	None known.	General soft tissue approximation and/or ligation, including use in cardiovascular, ophthalmic and neurological procedures.	6-0 through 5-0 with TAPERCUT* surgical needle 8-0 through 5-0 with taper point needle.	Royal Blue

Trademarks

The following are trademarks of ETHICON, INC.:

ATRALOC surgical needle
Coated VICRYL (polyglactin 910) suture
Coated VICRYL *RAPIDE* (polyglactin 910) suture
CONTROL RELEASE needle/needle suture
CS ULTIMA ophthalmic needle
ETHALLOY needle alloy
ETHIBOND *EXCEL* polyester suture capitalized
ETHICON sutures or products
ETHILON nylon suture
LIGAPAK dispensing reel
MERSILENE polyester fiber suture
MICRO-POINT surgical needle
MONOCRYL (poliglecaprone 25) suture
NUROLON nylon suture
PANACRYL braided synthetic absorbable suture
P PRIME needle
PC PRIME needle
PS PRIME needle
PDS II (polydioxanone) suture
PERMA-HAND silk suture
PROLENE polypropylene suture
PRONOVA poly (hexafluoropropylene-VDF) suture
RELAY suture delivery system
SABRELOC spatula needle
TAPERCUT surgical needle
VICRYL (polyglactin 910) suture
VISI-BLACK surgical needle

Surgical Needles

Necessary for the placement of sutures in tissue, surgical needles must be designed to carry suture material through tissue with minimal trauma. They must be sharp enough to penetrate tissue with minimal resistance. They should be rigid enough to resist bending, yet flexible enough to bend before breaking. They must be sterile and corrosion-resistant to prevent introduction of microorganisms or foreign bodies into the wound.

To meet these requirements, the best surgical needles are made of high quality stainless steel, a noncorrosive material. Surgical needles made of carbon steel may corrode, leaving pits that can harbor microorganisms. All ETHICON* stainless steel needles are heat-treated to give them the maximum possible strength and ductility to perform satisfactorily in the body tissues for which they are designed. ETHALLOY* needle alloy, a noncorrosive material, was developed for unsurpassed strength and ductility in precision needles used in cardiovascular, ophthalmic, plastic, and microsurgical procedures.

Ductility is the ability of the needle to bend to a given angle under a given amount of pressure, called load, without breaking. If too great a force is applied to a needle it may break, but a ductile needle will bend before breaking. If a surgeon feels a needle bending, this is a signal that excessive force is being applied. The *strength* of a needle is determined in the laboratory by bending the needle 900; the required force is a measurement of the strength of the needle. If a needle is weak, it will bend too easily and can compromise the surgeon?s control and damage surrounding tissue during the procedure.

Regardless of ultimate intended use, all surgical needles have three basic components: the attachment end, the body, and the point.

The majority of sutures used today have appropriate needles attached by the manufacturer. *Swaged* sutures join the needle and suture together as a continuous unit that is convenient to use and minimizes tissue trauma. ATRALOC* surgical needles, which are permanently swaged to the suture strand, are supplied in a variety

of sizes, shapes, and strengths. Some incorporate the CONTROL RELEASE* needle suture principle which facilitates fast separation of the needle from the suture when desired by the surgeon. Even though the suture is securely fastened to the needle, a slight, straight tug on the needleholder will release it. This feature allows rapid placement of many sutures, as in interrupted suture techniques.

The *body*, or shaft, of a needle is the portion which is grasped by the needleholder during the surgical procedure. The body should be as close as possible to the diameter of the suture material. The curvature of the body may be straight, half-curved, curved, or compound curved. The cross-sectional configuration of the body may be round, oval, side-flattened rectangular, triangular, or trapezoidal. The oval, side-flattened rectangular, and triangular shapes may be fabricated with longitudinal ribs on the inside or outside surfaces. This feature provides greater stability of the needle in the needleholder.

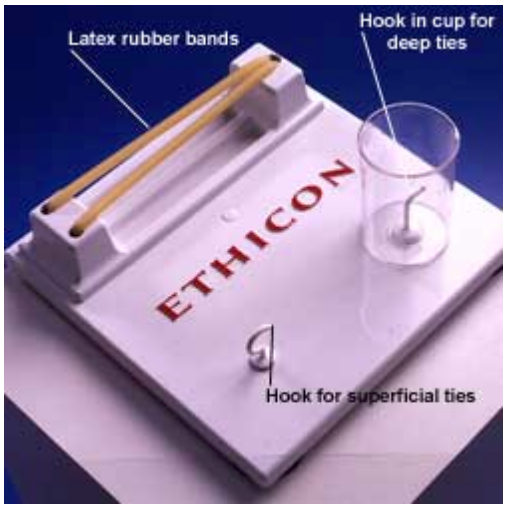
The *point* extends from the extreme tip of the needle to the maximum cross-section of the body. The basic needle points are cutting, tapered, or blunt. Each needle point is designed and produced to the required degree of sharpness to smoothly penetrate the types of tissue to be sutured.

Surgical needles vary in size and wire gauge. The diameter is the gauge or thickness of the needle wire. This varies from 30 microns (.001 inch) to 56 mil (.045 inch, 1.4 mm). Very small needles of fine gauge wire are needed for micro-surgery. Large, heavy gauge needles are used to penetrate the sternum and to place retention sutures in the abdominal wall. A broad spectrum of sizes are available between these two extremes.

Of the many types available, the specific needle selected for use is determined by the type of tissue to be sutured, the location and accessibility, size of the suture material, and the surgeon's preference.

Practice Board

Practice Board*



The KNOT TYING MANUAL and practice board are available from ETHICON, INC., without charge for all learners of suturing and knot tying techniques.

*Contributing Designer-Bashir Zikria, MD, FACS

Selected Terms

Absorption Rate	Measures how quickly a suture is absorbed, or broken down by the body. Refers only to the presence or absence of suture material and not to the amount of strength remaining in the suture.
Breaking Strength Retention (BSR)	Measures *tensile strength* (see below) retained by a suture *in vivo* over time. For example, a suture with an initial tensile strength of 20 lbs. and 50% of its BSR at 1 week has 10 lbs. of tensile strength *in vivo* at 1 week.
Extensibility	The characteristic of suture stretch during knot tying and recovery thereafter. Familiarity with a suture's extensibility will help the surgeon know when the suture knot is snug.
Memory	Refers to a suture's tendency to retain kinks or bends (set by the material's extrusion process or packaging) instead of lying flat.
Monofilament	Describes a suture made of a single strand or filament.
Multifilament	Describes a suture made of several braided or twisted strands or filaments.
Tensile Strength	The measured pounds of tension that a knotted suture strand can withstand before breaking.
United States Pharmacopeia (U.S.P.)	An organization that promotes the public health by establishing and disseminating officially recognized standards of quality and authoritative information for the use of medicines and other health care technologies by health professionals, patients, and consumers.